

## Final Progress Report

United States Army Research Office, Terrestrial Sciences

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Principal Investigator -- Dr. Paul R. Bierman

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### Statement of Problem

Currently, evaluating long-term rates of land surface erosion is a very difficult and uncertain task. Knowing such rates is imperative if land management decisions are to be made responsibly. Only if land managers can compare human-induced rates of surface change, with natural or background rates, can management decision be made cost-efficiently and with the best balance between preservation and use of the land.

In order to further this goal, we determined the background or natural rate at which soil and rock surfaces are eroding at three different sites: the Yuma Proving Ground (Yuma, AZ), the southern Mojave desert (near General Patton's former camp at Iron Mountain), and at Nahal Yael (an intensively studied, hyper-arid basin in the southern Negev of Israel). Such information is useful to land managers who need a context in which to evaluate responsibly the impact of Army mission activities.

### Summary of Most Important Results

This funding supported part-time salary, field, and analytic costs for seven students, a faculty member, and a technician to collect and analyze samples from two sites: Yuma Proving Ground, California and the Nahal Yael Research Watershed, Israel. In addition, salary support for Bierman and Clapp was used for the analysis of other related data sets including sediment samples collected from similar landscapes and modelling of complex exposure histories. The results of all of this research are reported in detail by the papers and abstracts listed in the next section.

In summary, our most important findings are:

- At Yuma Proving Ground, we determined that most sediment in upland drainages is derived from hillslopes and that rocky outcroppings are the most stable landscape features. This suggests that while rocky outcrops may be the landscape features most resistant to erosion they will also be the slowest features to recover from human impact.
- On the main stem of Yuma Wash, we determined that much of the sediment transported by the Wash is actually derived not from erosion of the highlands but from reworking of the older valley filling alluvium. This finding is important in terms of land management if the need arises to limit the sediment discharge from Yuma Wash. Limiting such discharge will require erosion control not only in the highlands but also in the valley.

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13. ABSTRACT (Maximum 200 words)  Currently, evaluating long-term rates of land surface erosion is a very difficult and uncertain task. Knowing such rates is imperative if land management decisions are to be made responsibly. In order to further this goal, we determined the background or natural rate at which soil and rock surfaces are eroding at two sites: the Yuma Proving Ground (Yuma, AZ) and at Nahal Yael (an intensively studied, hyper-arid basin in the southern Negev of Israel). At Yuma Proving Ground, we determined that most sediment in upland drainages is derived from hillslopes and that rocky outcroppings are the most stable landscape features. On the main stem of Yuma Wash, we determined that much of the sediment transported by the Wash is actually derived not from erosion of the highlands but from reworking of the older valley filling alluvium. At Nahal Yael watershed, we that long-term sediment generation rates are substantially less than short term sediment yields as measured by trapping the last 30 years of sediment transported out of the basin behind a retention dam. These findings suggest that short-term measurements of sediment yield may be overestimates.					
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- At Nahal Yael watershed, we found a similar pattern of stable bedrock and more rapidly eroding hillslopes. We also found that long-term sediment generation rates are substantially less than short term sediment yields as measured by trapping the last 30 years of sediment transported out of the basin behind a retention dam. These findings suggest that short-term measurements of sediment yield may be overestimates. Such a finding has important implications for the design of long-lasting engineering works such as dams and sedimentation control structures.

**List of Publications (supported in whole or in part by ARO funding of salary and/or analyses)**

*Refereed papers*

- Bierman, P., Clapp, E.M., Nichols, K.K., Gillespie, A.R., Caffee, M. (in prep.) Using cosmogenic nuclide measurements in sediments to understand background rates of erosion and sediment transport, *in Landscape Erosion and Evolution Modelling*, Harmon, R. S. and Doe, W. M., eds., Kluwer.
- Clapp, E. M., Bierman, P.R., Schick, A. P. Lekach, J., Enzel, Y., and Caffee, M., (in review), Differing rates of sediment production and sediment yield, **Geology**.
- Clapp, E., Bierman, P.R., and Caffee, M. (in review) Using  $^{10}\text{Be}$  and  $^{26}\text{Al}$  to determine sediment generation rates and identify sediment source in an arid region drainage basin, **Geomorphology**.
- Nichols, K.K., Bierman, P. R., and Caffee, M., (in review) Understanding desert Piedmonts using in situ produced  $^{10}\text{Be}$  and  $^{26}\text{Al}$ , **Geomorphology**.
- Clapp, E., Bierman, P.R., Pavich, M., and Caffee, M. (accepted) Rates of sediment supply to arroyos from uplands determined using in situ produced cosmogenic  $^{10}\text{Be}$  and  $^{26}\text{Al}$  in sediments. **Quaternary Research**.
- Nichols, K.K., and Bierman, P.R. (accepted) Fifty four years of ephemeral channel response to intense military activity at Camp Iron Mountain, Mojave Desert, California, *Environmental and Engineering Impacts of Military Operations*, **Geological Society of America Reviews of Engineering Geology**.
- Colgan, P.M., Mickelson, D. M., Bierman, P. R., Caffee, M. W., (in review) Variation in glacial erosion near the southern margin of the Laurentide Ice Sheet, south central Wisconsin, USA: implications for cosmogenic dating of glacial terrains: **Geological Society of America Bulletin**
- Schroeder, P.A., Nathan D., Melear, N.D., Bierman, P.R., Kashgarian, M., and Caffee, M.W., (accepted) Apparent gibbsite growth ages for the regolith in the Georgia Piedmont, **Geochimica et Cosmochimica Acta**.
- Bierman, P. R., Marsella, K. A., Davis, P. T., Patterson, C. and Caffee, M., (1999), Mid-Pleistocene cosmogenic minimum-age limits for pre-Wisconsinan glacial surfaces in southwestern Minnesota and southern Baffin Island -- a multiple nuclide approach. **Geomorphology**, 27, n 1 / 2, p. 25-40.

*Book chapters*

- Bierman, P. (in press) In situ produced cosmogenic isotopes: dating landforms and monitoring erosion rates. **Encyclopedia of Quaternary Science**.
- Bierman, P.R., Albrecht, A., Bothner, M., Brown, E., Bullen, T., Gray, L., Turpin, L., (1998) Weathering, erosion and sedimentation, In: Kendall, C., and McDonnell, J. J., **Isotope Tracers in Catchment Hydrology**, chapter 23, Elsevier

*Conference Proceedings*

- Clapp, E.M., Bierman, P.R., Caffee, M.W. (1999) Sediment generation and export rates in the Nahal Yale drainage basin, determined from cosmogenic  $^{10}\text{Be}$  and  $^{26}\text{Al}$ , Negev Desert, southern Israel, in **Drainage Basin dynamics and morphology, conference excursion, Negev Desert**, Lekach, J. and Hassan, M.A, eds., Hebrew University Jerusalem, p. 98-103.

#### *Abstracts*

- Bierman, P., Clapp, E., Caffee, M., and Schroeder, P. (1999) Understanding Earth surface processes with 10-Be (and a little 26-Al), **Geological Society of America Abstracts with Programs**. (National).
- Bierman, P., Clapp, E., Massey, C., and, Caffee, M., (1999) Tracing sediment through drainage basins with cosmogenic radionuclides,  $^{10}\text{Be}$  and  $^{26}\text{Al}$ . **International Conference on Drainage basin Dynamics and Morphology**, Jerusalem (International)
- Clapp, E., Bierman, P.R., and Caffee, M., (1999), Sediment generation and export rates in the Nahal Yael drainage basin, determined from cosmogenic  $^{10}\text{Be}$  and  $^{26}\text{Al}$ , Negev desert, southern Israel, **Geological Society of America Abstracts with Programs**, 31 (7), A-256. (National)
- Nichols, K.K, Bierman, P.R., Caffee, M. (1999) Long-term sediment dynamics of the Iron and Granite Mountain piedmonts, Mojave Desert, California, U.S.A., **International Conference on Drainage basin Dynamics and Morphology**, Jerusalem, Israel, p. 47
- Nichols, K. K. and Bierman, P.R. (1998). Geomorphic response to military training in the Mojave Desert. **Geological Society of America Abstracts with Programs**, 30 (7), A-143 (National)
- Clapp, E., Bierman, P. and, Caffee, M., (1998) Estimating long-term erosion rates in a hyper-arid region using in situ produced cosmogenic 10-Be and 26-Al in sediment and bedrock. **Geological Society of America Abstracts with Programs**, 30 (7), A-361. (National)
- Clapp, E. M. and Bierman, P. R. (1997) Rates of erosion determined using in situ produced cosmogenic isotopes in a small arroyo basin, northwestern New Mexico **Geological Society of America Abstracts with Programs**, 29 (7), A-371 (National).

#### **Advanced degrees Earned by Project Personnel**

Kyle Nichols, MS, 2000

Erik Clapp, Ph.D., ABD (expected completion, Fall 2000)

#### **Students and faculty supported in whole or in part by ARO funding**

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